1938

A turntable method for testing liquid household insecticides against house flies.

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A TURNTABLE METHOD FOR TESTING LIQUID HOUSEHOLD INSECTICIDES AGAINST HOUSE FLIES

SULLIVAN - 1938

A Turntable Method for Testing Liquid Household Insecticides Against House Flies

by

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Thesis submitted for degree of

Master of Science

Massachusetts State College, Amherst.

1938

Analytical Outline

* * *

INTRODUCTION

The Bureau of Entomology (now Entomology and Plant Quarantine) in cooperation with the Insecticide Division of the Bureau of Chemistry and Soils (now Division of Insecticide Investigations of Entomology and Plant Quarantine) in 1931 undertook the testing of various chemicals for possible insecticidal action. The house fly was chosen as the test insect because Glaser (6)[1/] and others had successfully reared it through the whole year and it has proved to be a good test insect for the comparison of the relative toxicity of various contact poisons when a fairly large difference in toxicities is present in the samples to be tested. An outgrowth of this investigation was the development of an accurate technique for testing the toxicity of certain insecticides to mosquito larvae by Dr. F. L. Campbell and the writer (2, 4). The further need for a rapid and efficient method of testing certain contact insecticides has resulted in the development of the turntable method reported in this paper.

[1/] Numbers in parentheses refer to Literature Cited page 24.

Review of Laboratory Methods Proposed for Testing Liquid Household Insecticides Against House Flies

The literature on the subject of testing liquid household insecticides against the house fly shows that the methods fall into three classes. A brief outline of equipment and procedure used in these methods will be given.

I. Methods determining kill of insect when brought into contact with a settling spray mist: Liquid household insecticides are usually tested by the Peet-Grady method (10). The testing chamber in this method consists essentially of a small cubical room 6 feet on a side with a glass window in the center of the ceiling and in three of the walls. The fourth wall has a tight closing door large enough for a man to enter. The walls each have four square ports covered with tight fitting hatches. Each wall has two one-half inch holes six inches from the ceiling and closed with corks.

Approximately 100 flies are liberated in the chamber and the insecticide introduced through the one-half inch holes along the ceiling by means of a modified De Vilbiss atomizer. Twelve cc of the test solution are used for each test. A test runs for 10 minutes when the ports are all opened and an exhaust fan turned on. The flies that have dropped are gathered up and transferred to observation cages where they are fed and held for 24 hours before final counts are made. It is considered that flies off the floor at the end of the 10 minute-period have escaped the action of the insecticide.

The major changes and additions to the Peet-Grady method as suggested by Mr. F. C. Nelson (8) are as follows:

1. The adoption of more than one dosage per sample in order to obtain a kill of approximately 50%.
2. The adoption of a standard check.
3. Inclusion of moribund with dead flies in 24 hour counts.
4. The addition of paralysis readings during the 10 minute exposure time to show speed of paralytic action.

A great reduction in the size of the spray chamber and the "caging" of the test insects is another variation of the settling fog method of testing insecticides.

The design of the metal turntable used for this thesis was developed by F. L. Campbell and the writer evolved from its simpler and less effective predecessors through several stages of evolution. The first apparatus (4) consisted of a paint spray gun, mounted rigidly on top of a flanged bell jar which rested on a glass cylinder. A copper tray at the base of the cylinder served as the container for a six inch screened Petri dish holding the flies which were exposed to the misty spray. The performance of this apparatus was very good but only 12 tests could be run in a day's time.

The above method was modified in the interest of speed so as to give progressive treatment in a row of cylinders (3). Six cylinders were placed in line, each resting on a glass plate. The bell jar with mounted gun was placed on the cylinder to the left of the line. Immediately after spraying, the bell jar was lifted slightly while a glass plate was slipped over the cylinder and the bell jar was then placed on the plate over the second cylinder. The first cylinder was then tilted back while a dish of flies was slipped under it and a stop watch started. This process was repeated until the six treatments, taking five minutes in all, were made in order. The principle advantages of this method were speed and simplicity, 36 tests being easily made in a day. The drawback was that it took two people to operate it.

An offshoot of the original bell jar method for testing house flies was developed by Zermuehlin and Allen (13). The changes made were essentially in the method of exposing insects to the settling mist, and the elimination of transferring the treated flies to separate observation cages.

II. Methods determining time of paralysis of insects: An insecticidal method for the estimation of the paralysis time of extracts of pyrethrum has been devised by H. H. Richardson (11).

The apparatus consists of a rectangular box (2.5 x 2.5 feet) with a glass top and sides—one side built so that glass can be moved back and forth. A copper wire screen testing cage (1.5 x 2.5 x 1.5 feet) is placed on the inside of the box at one end. A spraying device is centrally located on the outer side of this cage with the nozzle projecting into the testing chamber. An electric fan is situated at the end of the large box opposite the atomizer.

About 50 house flies are introduced into the wire screen cage, the box closed tightly, the fan switched on. One and six tenths cc of spray is atomized into the cage where it is distributed by the air current from the fan. At 30-second intervals, counts are made of the number of paralyzed flies until well over 50 per cent of the flies are down. At the conclusion of the test the flies are counted and transferred into a cylindrical cage, fed, and the dead and living flies counted after 24 hours.

A method of testing liquid insecticides consisting of a lethal chamber 14 x 14 x 32 inches with a window for observation purposes and a door 8.5 x 8.5 inches has been devised by L. W. Dickey (5).

A small rotating rod passes through the top on the center line of such a length that the top of the fly cage when suspended on it is 4 inches from the top of the chamber. The fly cage is screened in the form of a cylinder 3 inches in diameter and 6 inches high, with removable bottom.

Ten flies are introduced into the cage and a De Vilbiss atomizer placed flush against the front of the chamber through an orifice in the center. As the trigger is pulled the cage is rotated one-half turn in the time taken to deliver the 0.4 cc of the insecticide. The time in seconds required for the paralysis of each insect is noted and the result of the test is expressed as the average of the time required to paralyze each insect.

III. A drop method for determining kill of insects: This method was developed by F. C. Nelson et. al. (9).

Approximately 60 flies of known age are chilled and then removed to a cold marble block where they are separated for uniformity of size and are all turned on the backs, 0.75 mm of a mixture of 9 parts absolute ethyl alcohol and 1 part by volume of the insecticide to be tested is measured out in a finely drawn capillary pipette and placed on the center of the ventral surface of the thorax of each fly while still inactive. These treated flies are then transferred to glass dishes, fed, and set aside for 24 hours observations. The active flies are allowed to escape when the 24 hour observation was made, making it necessary to count only the dead and moribund flies.

P R O C E D U R E

The turntable method was devised to save time and labor and to obtain greater uniformity of application of the liquids to be tested. Instead of the spray gun being moved from one cylinder to another, the cylinders were moved on a turntable under a fixed spray gun. The first turntable was of wooden construction and contained 6 glass spray chambers (7). The wooden turntable proved to be a rather accurate and efficient outfit but in time the wooden surface of the table warped, the class cylinders chipped and in general need was felt for a more stable outfit with a greater test capacity. The present all metal turntable containing ten spray chambers was designed and built to fulfill these requirements.

Description of new metal turntable: The new metal turntable is shown in Figures 1 and 2*. The frame of the table is of steel construction. The table contains 10 cylinders (17 inches high and 8 inches in diameter) and revolves on ball bearings. The turntable is entirely of aluminum construction except for the slides which are of stainless steel. The surface of the table (42 inch diameter) is constructed with two sheets screwed together and patterned so as to provide grooves for the slides upon which the cylinders rest and an indented circle to hold the cylinders in place. The cylinders have a circular lid with a 3/4 inch hole, directly in the center through which the spray enters the chamber.

A Petri dish containing the flies to be tested is placed in a

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*The details of construction were done by G. R. Elwell, Bureau of Lighthouses, U. S. Department of Commerce.

Fig. 1 — 34422 - C. The Campbell Turntable. Adult houseflies in a screen covered Petri dish about to be placed in the cuplike retainer in the lower left of picture. The slide is then pushed home and the cylinder put in place.

Fig. 2 — 34416 - C. The Campbell Turntable. Five cc of a liquid household insecticide being poured into funnel feeding the spray gun. The liquid is sprayed under 5 pounds pressure into the aluminum cylinders as a fog like mist. Flies are exposed for 10 minutes to this settling mist by removing the slide and placing it in slide holder (lower center picture). The Erlenmeyer flask located over the gun contains acetone for cleaning the gun between applications. Ten tests of 100 flies each can be run easily in 20 minutes.

cup (4 inches deep and 5.25 inches in diameter) with a movable bottom. This receptacle can also serve for cages containing a variety of insects susceptible to this treatment.

A ratchet with stops on the aluminum ribs supporting the table assures a perfect alignment of gun and cylinder holes.

The spray gun is supplied with two lines of compressed air; a high pressure line to operate the plunger and a low pressure line regulated by a reducing valve to desired pressure (5 lb. per square inch) which atomizes the liquid entering into the gun from the thistle tube. An Erlenmeyer flask containing acetone cleans the gun between different treatments.

Operation of new metal turntable: A series of 40 tests is made as follows: The food is removed from 10 Petri dishes containing recently fed flies and they are placed in the cups on the turntable. This operation is carried out by removing #1 cylinder, placing the Petri dish in the cup underneath, pushing the slide all the way in the groove, and removing the cylinder to the right placing it in position over the slide. This leaves an exposed cup to the right where the operations are repeated until the 10 fly containers are in place.

The liquids to be tested are measured out in advance, 5 cc to a tube, and placed in numbered racks. The temperature of the testing room is kept constant (25°C).

With cylinder #1 in place under the spray gun, the operator pours the contents of the first test tube into the thistle tube leading to the gun, sprays the entire 5 cc into the cylinder (except for small amount always left in gun) and pulls the slide at the chosen time interval. Preliminary tests determine the correct timing between spraying and pulling the slide that will give the desired kill for liquid to be tested. The gun is then cleaned with acetone, when advisable, by opening a stopcock which releases acetone from the reservoir into the thistle tube. The operator then turns the table until the ratchet catches on the next stop bringing cylinder #2 in place and repeats the procedure 30 seconds after the first spraying.

Cylinder #1 is removed after standing over the flies for 10 minutes, the flies transferred to 9.5 inch cubical cages and later placed in an adjacent constant temperature room (Fig. 3.). At 30-second intervals the remaining cylinders are moved to the vacated position to the left and the flies transferred to cages. This gives a 10 minute exposure period to all flies. The cylinders and table are cleaned, a second set of 10 dishes of flies brought in and the cycle is repeated. The 40 treatments require about 1.5 hours. Milk soaked cotton is then supplied as food for the flies.

Methods of rearing and handling flies for testing purposes: The egg supply for rearing purposes is furnished from stock cages containing about 1500 flies each. Egg laying starts in 3 or 4 days after emergence, and large masses are readily obtained within 3 hours of placing milk soaked cotton wads in the corners of the cages. At all other times the fly food is milk and water (formalin 1-2000 added) in custard jars with a round piece of perforated cork serving as a float to keep flies from drowning. Under ordinary

Fig. 3 — 34421 - c. Removing recently tested flies to observation cages. The flies have been rendered immobile by the fly spray. The back of the observation cage is made of rubber inner tubing and entrance to cage is through hole plugged with cap and the sliding glass front window. The handle in left center of picture operates the spray gun. The removable wire screen with celluloid collar is shown in front of cage.

conditions this eliminates all egg laying except when cotton wads are in place and makes it possible to get a supply of eggs within a few hours of the same age.

It is essential that each jar contain nearly the same number of eggs if the adult population is to be uniform in size. A method was developed that seems to be a satisfactory solution of this problem. Approximately the desired number of egg masses (6-7) were placed in a 250 cc Erlenmeyer flask containing 150 cc of water. The flask was shaken vigorously until the egg masses were dispersed. The eggs were allowed to settle, the supernatant liquid decanted, and a portion of the remaining, containing the eggs, poured into a 15 cc graduated centrifuge tube. The eggs were allowed to settle, the volume occupied by the eggs noted, and additional eggs added until the required volume was reached. The eggs settle out into a level mass and it has been found by experimentation that the amount of food used in our jars, 1.0 cc of eggs gives the correct sized adults.

The eggs are put in a jar containing a bran-alfalfa meal mixture devised by H. H. Richardson (12), slightly changed to suit our requirements. Two parts of bran and one part of alfalfa meal (by weight) were thoroughly mixed and stored as a stock supply. In a battery jar (9" x 10") was placed 1.2 kilograms of this mixture and to this was added a mixture containing 2500 cc of water, 40 cc Diamalt, and 150 cc of a yeast suspension from a stock suspension containing 1/2 pound of bakers yeast per liter of water. Thorough mixing produced a paste-like substance which has all the requirements for the development of normal healthy flies.

In a room having a temperature of 28°C. and 20-40% relative humidity most of the larvae are full grown in 8 days time and some few have pupated. The jars are then inverted on one of the screened sections of a stand. The full grown larvae soon migrate through the screen into enameled milk pans containing a fine sawdust. There is an almost complete migration over a 2 day period.

The larvae, in the sawdust, are placed in a constant temperature cabinet (temperature 28°C., relative humidity 75%) to prevent dessication. Daily the newly formed puparia are separated from the larvae by placing them in a 16-inch square frame with a 12-mesh screen bottom and sifting. The frame is supported by a garbage can lid which serves to collect the sawdust sifted through and the larvae that rapidly crawl through the mesh leaving clean puparia. The puparia are then measured into screened Petri dishes placed either in a constant temperature cabinet or when an oversupply occurs, into a room of lower temperature. The measuring is done by counting our a sample lot lf 115 puparia noting the volume occupied in a centrifuge tube. Subsequent lots of the same volume are then rapidly measured.

The adults start emerging in 3 days and the flies are ready for testing in 6 days. Approximately 90% of the puparia yield healthy adults and are fed by placing a wad of cotton soaked in milk and protected from the screen by a piece of filter paper, on top of the Petri dish. Figure 4 gives a view of the constant temperature room where the flies are bred and later held for observation purposes.

Fig. 4 — 34417 - c. Observing the flies after treatment with various liquid household insecticides on the Campbell Turntable. One will note that all flies appear to be dead in the cage held by the observer. To the immediate left is another cage in which the flies were unaffected by the treatment. Maggots are reared in the bran-alfalfa yeast mixture in the jars in the upper left of the picture. Opposite jars are 2 stock cages of flies from which eggs are collected daily. On the next shelf are Petri dishes containing the flies to be tested. Milk soaked cotton separated from the screen by filter paper is used to feed the flies.

EXPERIMENTAL RESULTS

Investigations to determine the performance of the all-metal turntable under varying conditions: Burdette (1) and others have made rather intensive investigations as to the optimum conditions of toxicity for fly sprays as controlled by varying pressures and nozzle openings. Burdette found a pyrethrum-oil base spray to be most efficient as an air float when atomized so that at least 90 per cent of the available liquid volume occurs in drop sizes ranging from 1 to 10 microns in a concentration of 0.032 cc per cubic foot of space. He also reported that the production of the optimum concentration of the optimum size is dependent upon the pressure and nozzle opening, and liquid flow of the apparatus for producing air float. For example, against Honey bees a De Vilbiss spray gun produced an optimum concentration of 0.032 cc per cubic foot of 1 - 10 micron particle size by using 16 pounds pressure with the nozzle partially open.

Using this work as a guide a stody was made of the relationship of size of oil particles sprayed, weight of spray deposit, and pounds of spray pressure, to the toxicity of house flies on the turntable.

Effect of spray pressure on deposit: Five cc portions of a highly refined kerosene was sprayed into the aluminum cylinders at 5, 10, 15, and 20 pounds pressure. Glass slides (3 1/2" x 4") were exposed to the falling mist for 10 minute periods immediately after the gun stopped spraying. The glass slide was laid in the center of a Petri dish and a wire screen placed over the dish to duplicate the conditions actually found when testing various toxic substances against house flies. Another glass slide of similar dimensions was then superimposed, making a "sandwich". All slides had previously been dried in an oven to a constant weight and placed in a dessicator. The average weight of the spray deposit (5 tests) for each condition is shown in Figure 5. It will be noted that the deposit falls from 28.9 mg at 5 pounds pressure to 13.3 mg at 15 pounds pressure and then levels off. Increasing the pressure probably causes more and more of the oil particles to be thrown violently against the sides and bottom of the cylinder thus reducing the volume of the settling mist. Also, the higher pressure would vaporize more of the oil and thus reduce the volume of oil in the liquid stage in the cylinder.

Effect of spray pressure on size of oil particles: The procedure used was as follows: A saturated solution of a red oil dye was made with a highly refined kerosene in order to render the particles more visible under the microscope and more readily distinguishable from small organisms or other foreigh matter. A 4 per cent solution of liquid cocoanut oil soap in distilled water was prepared and a small drop of this soap solution placed on a cover glass with a medicine dropper. The Petri dish containing the cover glass was placed at the bottom of the mist cylinder. Five cc of the colored oil was sprayed into the cylinder under a pressure of 5 pounds. When no more spray came through the spray gun, the slide at the bottom of the cylinder dividing the mist from the Petri dish was pulled out, exposing the drop of liquid to the falling oil particles. After

5 seconds of such exposure the Petri dish was taken out, the cover glass inverted and placed on a ring of vaseline on a microscopic slide to form a hanging drop. The kerosene particles are suspended in the water of the hanging drop, the soap in the water forming a film about the particles and largely preventing their coalescence during the course of the measurements. The suspended particles were measured by means of an ocular micrometer, the particles measured being taken as observed, an attempt being made to get a random sample in that way. One hundred particles were measured for the 5 pounds pressure (or as many as could be found in the drop up to 100), then 100 for the 10, 15, and 20 pounds pressure in that sequence. This process was repeated 10 times until approximately 4000 measurements were made, about 1000 for each of the four pressures. The results are shown in Figure 6.

A drop in size from 11.51 microns for the 5 pound pressure to 5.67 microns for the 20 pound pressure was recorded. This would be expected as the increased force of impact between air and liquid caused by the higher air pressures would result in a finer dispersion of the oil.

Effect of spray pressure on toxicity to house flies: For this work a pyrethrum spray containing approximately 1 mg. pyrethrins per cc of a highly refined kerosene was used. Ten tests of 100 flies each were run at each of the 5, 10, 15, and 20 pound pressure. The flies were exposed to the falling mist (immediately after the gun stopped spraying the exposure continuing for 10 minutes). Results are shown in Figure 7.

A drop in mortality from 60 per cent to 23 per cent was obtained when the spray pressure was increased from 5 pounds to 10 pounds, This is about what would be expected since we have found that increasing the spray pressure from 5 pounds to 10 pounds had caused about a 1/2 reduction in the weight of the spray deposit (Figure 5). It might also indicate that the smaller sized oil particles were less effective than the larger ones.

Effect of delay in exposure on spray deposit: In a second series of tests the air pressure was kept constant at 5 pounds, but there was a delay of 0, 5, 10, and 15 seconds, respectively, in pulling out the slide after the spray gun stopped. The rest of the procedure was the same as for the first series. Results of these tests are shown in Figure 8.

It will be noted that slides exposed directly after spraying gave a deposit of 28.9 mg which was decreased to about half with a 15 second delay in exposing the slides. In other words, over a 10 minute period, almost 1/2 of the mist in the cylinders is deposited in the first 15 seconds. This confirms results obtained on the old wooden turntable and stresses the need of accuracy in operation.

Effect of delay in exposure on size of oil particles: Approximately 3000 oil particles were measured at a constant pressure of 5 pounds, with delays in exposing the cover glass of 0, 5, 10, and 15 seconds. The results are shown in figure 9. When the slides were exposed immediately the average size of the oil particles was 11.51 microns which dropped to 6.31 microns on a 15 second delay in exposure. The larger, heavier oil particles had settled out within a few seconds leaving a rather uniformily sized mist. Accordingly, with the use of kerosene as a carrier, it is best to delay the time of exposure so as to get a more uniform spray on the flies.

Effect of delay in exposure to toxicity to house flies: In this group of tests the spray pressure was kept constant at 5 pounds while there was a delay of 0, 5, 10, and 15 seconds in exposing the flies. The rest of the procedure was the same as described under "Effect of spray pressure on toxicity to house flies". The results are shown in Figure 10. As would be expected from the above studies, there was a big drop in toxicity corresponding to the increased spray pressure. With the use of the curve shown in Figure 10, a wide range in mortality can be obtained by regulating the time of exposure.

Selection of a suitable set of constant conditions for testing: It is desirable that the turntable produce results that are in line with those given by the Peet-Grady method. Tests on the wooden turntable using pyrethrins at the usual concentrations always gave lower kills than were obtained by the Peet-Grady method. By a manipulation of the various factors affecting the kill of house flies (Figure 5 - 10) we were able to adjust the kill to a satisfactory level. These constant conditions for tests against house flies on the all metal turntable are:

1. Flies 2 - 3 days old, in good condition, and fed within 2 hours of tests.

2. Twelve mesh wire screened Petri dishes used as containers for flies.

3. Equipment adjustments:
   - A. Five pound air pressure while spraying.
   - B. Plunger valve open 6 turns.
   - C. Liquid feed valve wide open.
   - D. Round type spray adjusted at "0".

4. Five cc of liquid used for each test.

5. Gun turned off directly when liquid ceased to be sprayed.

6. Interval between spraying and exposure of flies to falling mist.

   A. When oils like kerosene are used as solvent of spray - delay of 6 seconds in exposing flies. (after gun stops spraying)

   B. When more volatile solvents as acetone, alcohol, and petroleum ether are used as solvents - flies are exposed immediately.

7. Flies exposed to the falling mist for a 10 minute period.

Using these constant conditions, a series of experiments were run to test the reliability of results. The official control sample (O.C.I.) was run against a "liquid insecticide" which might represent any unknown sample being checked with the standard for its effectiveness as an insecticide. The official control method (N.A.I.D.M.) of evaluating comparable tests was used in the statistical treatment of results shown in Table I.

The figure 2.839 indicates the tests have been properly conducted and that reproducable results are obtained with the use of the Campbell turntable.

Table 1

OFFICIAL METHOD OF EVALUATING COMPARATIVE TESTS

OF THE 1937 O.C.I. SAMPLES AND THE

"LIQUID INSECTICIDE" (C.I.#1100)

Campbell turntable method - 1 day kill

Pair	Date	Batch	"Liquid Insecticide" (C.I.#1100) % Kill	O.C.I. (C.I.777) % Kill	Difference	Deviation from Mean Difference	Squared
1	5/20/37	5/17-18/37	62	27	+35	+ 7.1	50.41
2	5/20/37	5/17-18/37	41	35	+ 6	-21.9	479.61
3	5/20/37	5/17-18/37	67	28	+39	+11.1	123.21
4	5/20/37	5/17-18/37	56	23	+33	+ 5.1	26.01
5	5/20/37	5/17-18/37	48	20	+28	+ .1	.01
6	5/20/37	5/17-18/37	52	22	+30	+ 2.1	4.41
7	5/20/37	5/17-18/37	41	17	+24	- 3.9	15.21
8	5/20/37	5/17-18/37	49	25	+24	- 3.9	15.21
9	5/20/37	5/17-18/37	53	24	+29	+ 1.1	1.21
10	5/20/37	5/17-18/37	53	22	+31	+ 3.1	9.61
			52.2M	24.3M	27.9M.D.	0.0	724.90 Sum d^2

Mean difference = 27.9

$$\text{Standard error of M.D.} = \frac{\sqrt{\frac{\text{Sum } d^2}{n-1}}}{\sqrt{n}} = \frac{\sqrt{\frac{724.9}{9}}}{3.16} = 2.839$$

DISCUSSION AND CONCLUSIONS

Liquid household insecticides are usually tested in cubical chambers 6 feet on a side by the method described by Peet and Grady (10). This method was intended to give reproducible results and at the same time to simulate conditions under which fly sprays are applied in practice. However, it has not made practical tests unnecessary and has come to be used chiefly for controlling the quality of commercial fly sprays, for determining the relative value of different brands of household insecticides and for testing new insecticides. For these purposes the Peet-Grady method might well be replaced by one that is more rapid; provided it gives equally dependable results. With this in mind F. L. Campbell and the writer developed the all metal turntable. Methods of rearing and handling house flies were changed to conform with the altered technique of testing fly sprays.

The effect of varying pressure and length of exposure to kill of house flies showed that kerosene sprays containing pyrethrum gave a satisfactory kill when five pounds pressure was used with exposure delayed 10 seconds. Measurements showed that most of the larger oil particles had settled out during this period. A statistical treatment of date obtained from running fly tests on the turntable gave satisfactory results.

It is believed that the all metal turntable described in this thesis will prove of value in laboratories which wish to use a fast and accurate laboratory method for testing the toxicity of contact poisons.

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A C K N O W L E D G M E N T S

I wish to acknowledge the supervision and helpful suggestions given me by Dr. H. L. Sweetman assistant professor of entomology, Massachusetts State College, Dr. F. L. Campbell, formerly of the Bureau of Entomology and Plant Quarantine and now associate professor at Ohio State University, and Dr. L. A. Hawkins and Dr. E. R. McGovran of the Bureau of Entomology and Plant Quarantine, in the preparation of this thesis.

* * *

Approved by:

R. W. Fessenden

W. H. Davis

Harvey L. Sweetman

Graduate Committee

Date: Oct. 10, 1938

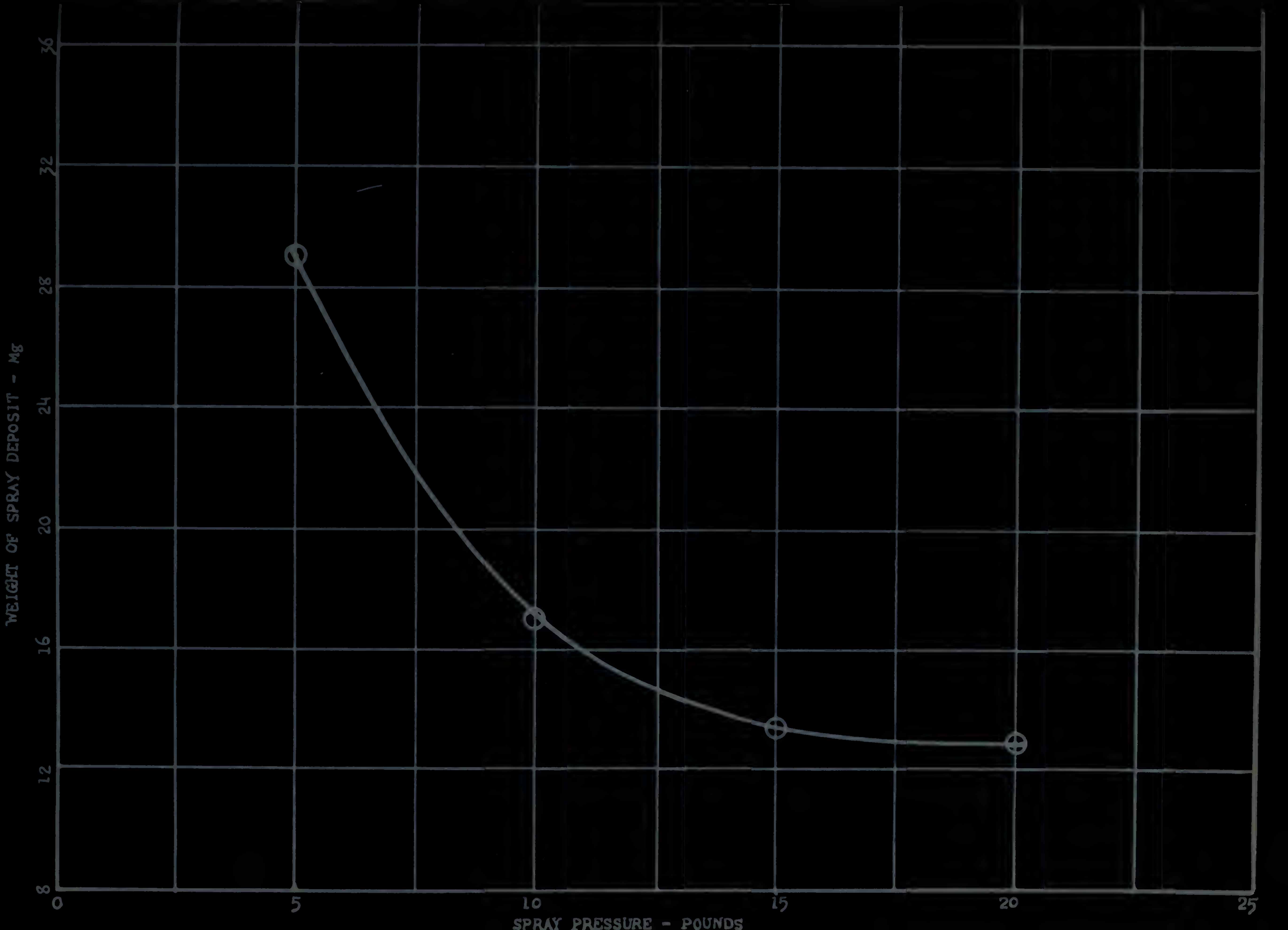
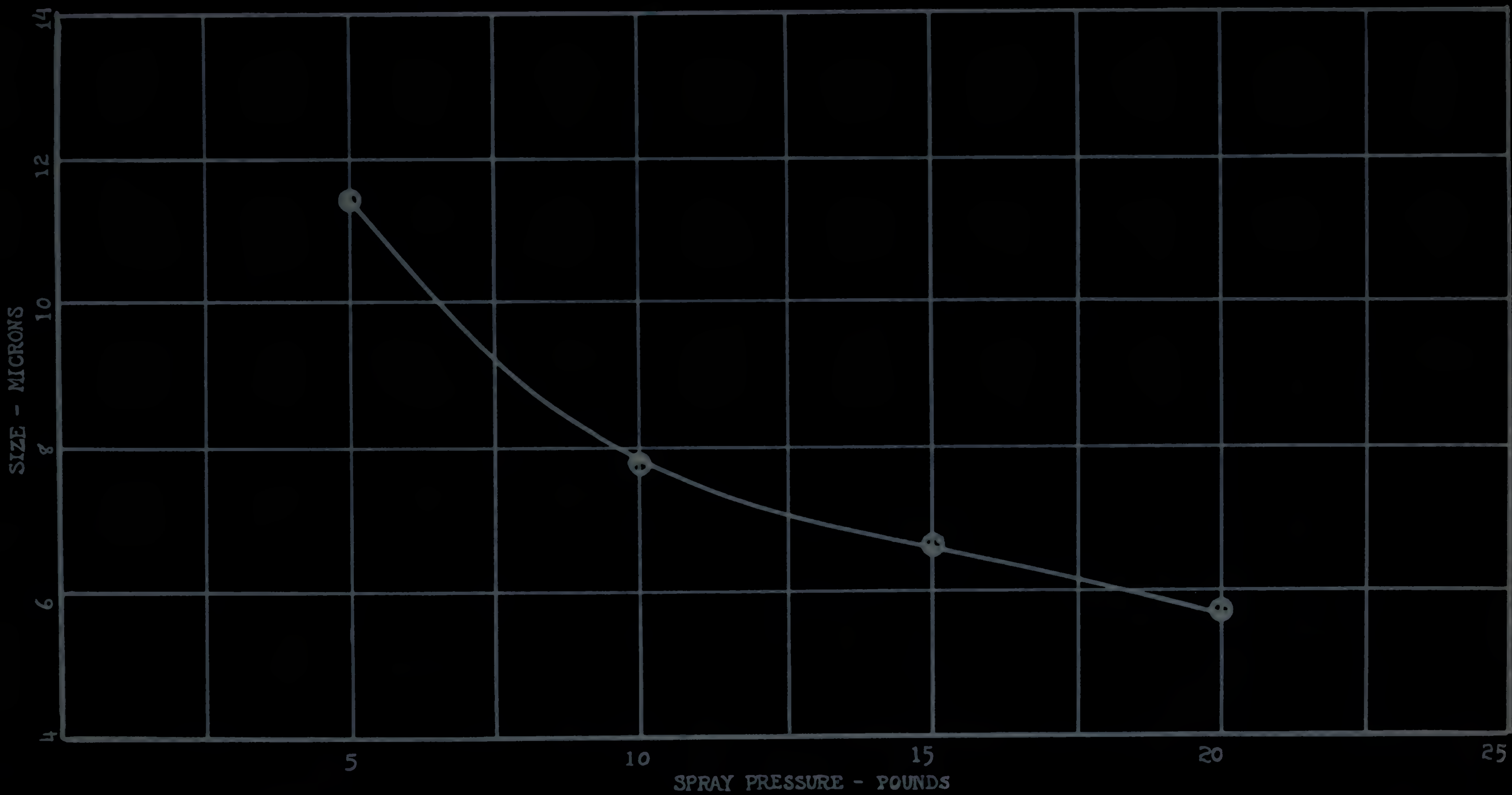
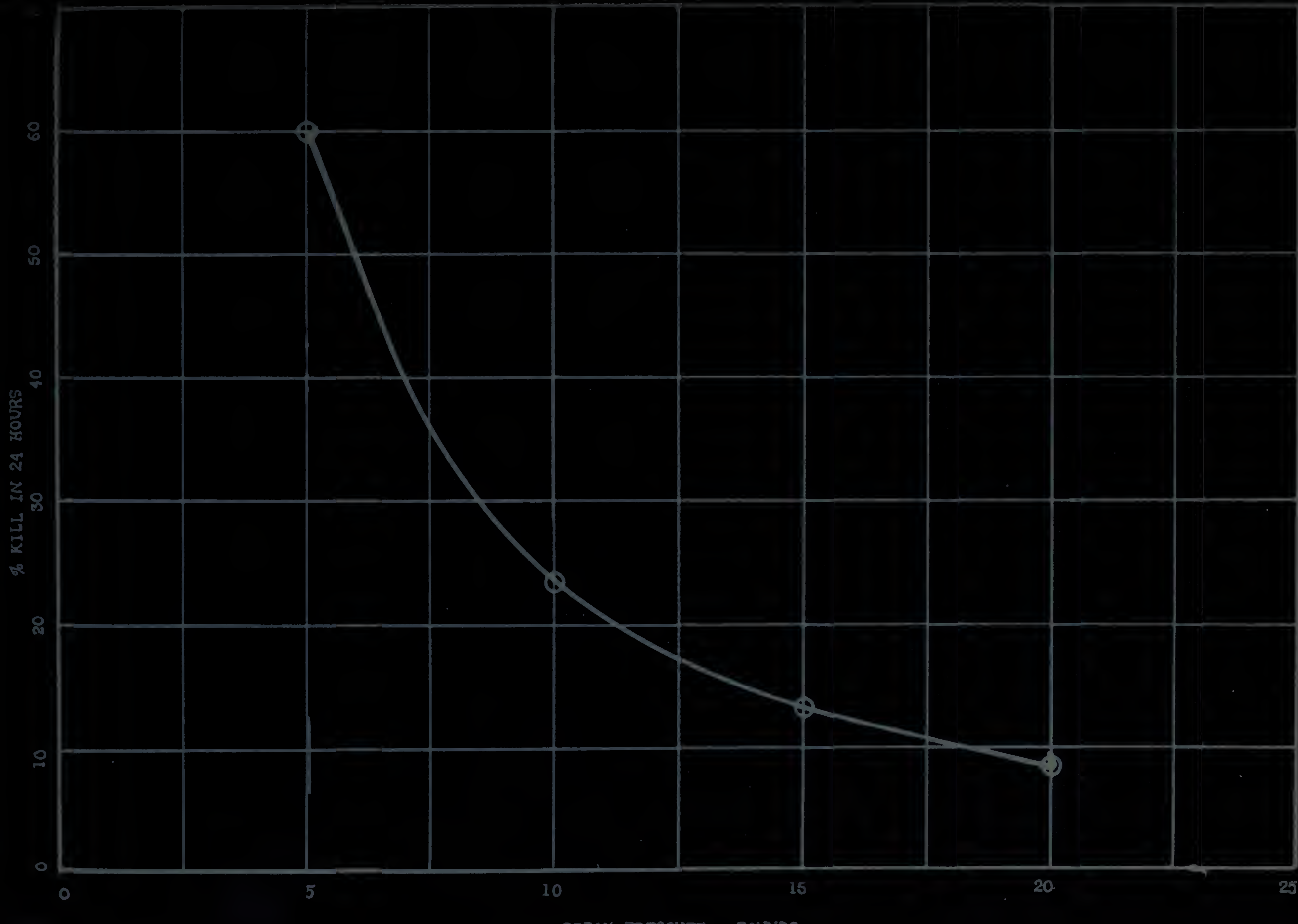
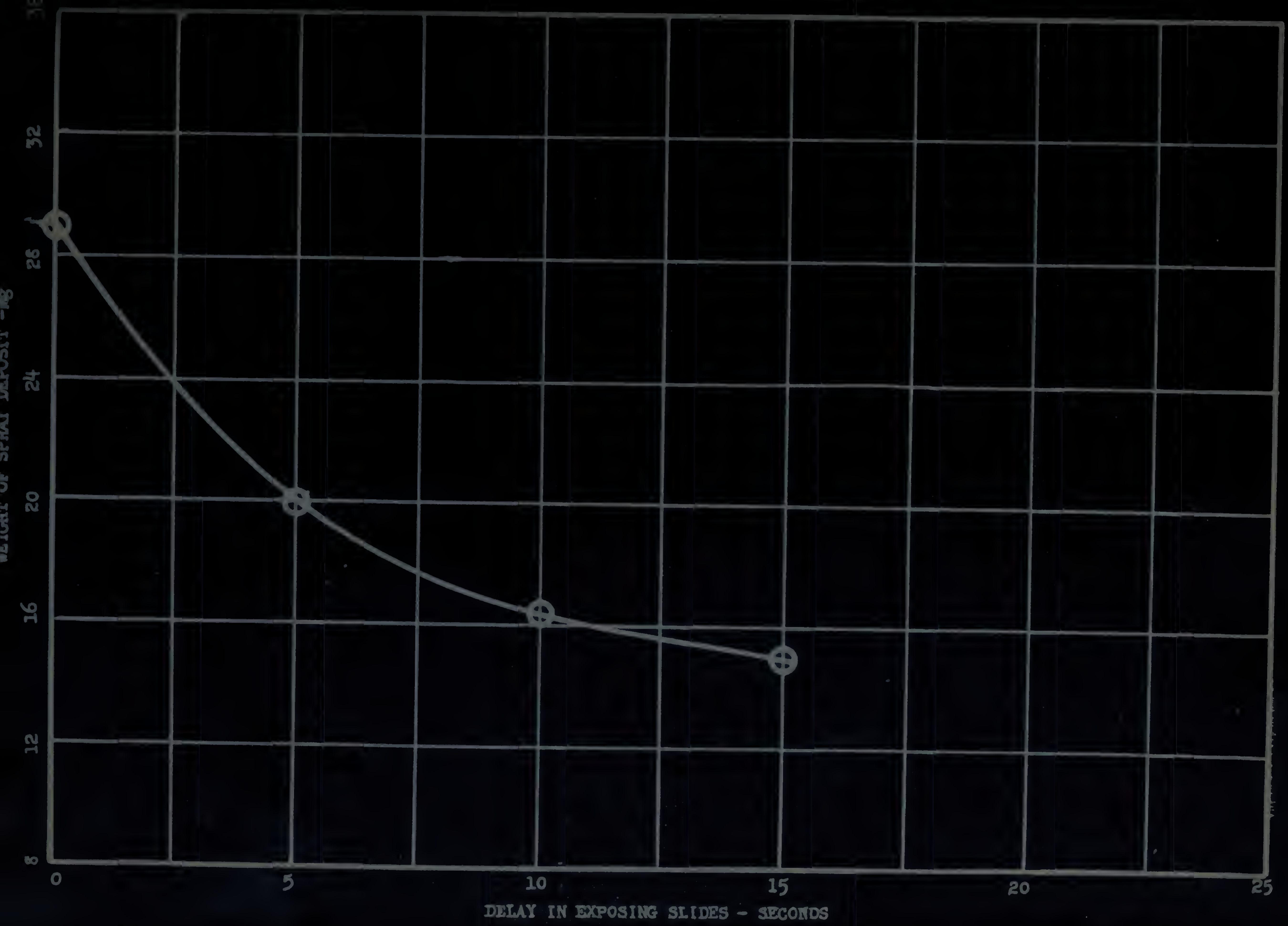

WEIGHT OF SPRAY DEPOSIT - Mg
SPRAY PRESSURE - POUNDS
36
32
28
24
20
16
12
8
0
5
10
15
20
25

FIG. 6 - EFFECT OF PRESSURE ON SIZE OF OIL PARTICLES

(No delay in exposing cover glasses)




% KILL IN 24 HOURS
0
10
20
30
40
50
60
0
5
10
15
20
25
SPRAY PRESSURE - POUNDS.



WEIGHT OF SPRAY DEPOSIT - mg
8
12
16
20
24
28
32
0
5
10
15
20
25
DELAY IN EXPOSING SLIDES - SECONDS

FIG. 9 EFFECT OF DELAY IN EXPOSURE ON SIZE OF OIL PARTICLES

(Pressure constant at 5 pounds)

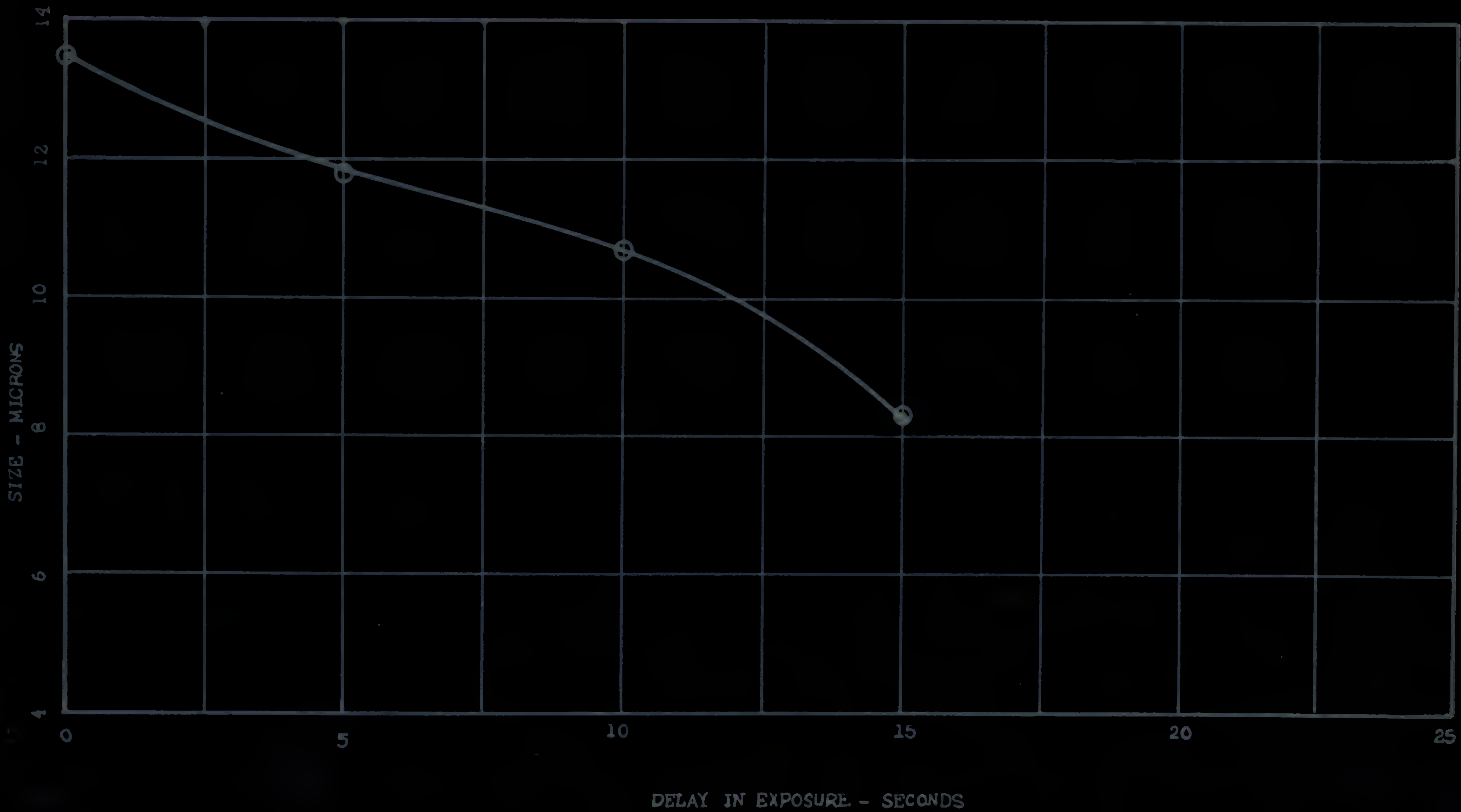


FIG. 10 - EFFECT OF DELAY IN EXPOSING HOUSE FLIES ON KILL
(Pressure constant - 5 pounds)